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INDIUM [ADVANCE RELEASE]

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Indium

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Indium was not recovered from concentrates in the United States during 2015. Several facilities imported indium metal for the production of high-purity indium metal, indium compounds, specialty indium alloys, and other indium products. During 2015, U.S. imports for consumption of unwrought indium metal and indium powders were 140 metric tons (t), a 14% increase from the 123 t imported in 2014 (table 1). Global primary refined indium production was estimated to have decreased by 14% to 759 t in 2015 from the revised 2014 quantity (table 3).

Production

Globally, zinc concentrates were the principal source of primary indium. Although the United States was a significant producer of zinc concentrates, indium was not known to be recovered from these concentrates domestically or in other countries. In 2015, one indium-containing deposit in the United States has progressed towards development in recent years—InZinc Mining Ltd.'s (Canada) West Desert zinc-copper-iron-indium deposit in Utah. InZinc Mining released a preliminary economic assessment of West Desert in 2014 that projected that an average of about 38 metric tons per year (t/yr) of indium could be produced from the zinc concentrate during a 15-year mine life (InZinc Mining Ltd., 2015).

A significant amount of indium-containing scrap was recycled domestically; however, sufficient data were not available to estimate the quantity of indium recovered or recycled back into new indium products.

Consumption

Domestic indium consumption, based on import levels, was estimated to have ranged between 100 and 150 t/yr during the past 5 years. Imported indium metal was either upgraded to higher purities and (or) consumed for the production of indium alloys, chemicals, shapes, and specialty products, which were sold to downstream users. Indium Corp. of America (ICA) (Utica, NY) and Umicore Thin Film Products (Providence, RI, a division of Umicore NV, Brussels, Belgium) accounted for the majority of U.S. consumption of indium. Other companies that consumed indium in the United States included 5N Plus Semiconductors LLC (St. George, UT), ACI Alloys Inc. (San Jose, CA), AIM Specialty Materials USA (Cranston, RI), Crystacomm Inc. (Mountain View, CA), ESPI Corp. Inc. (Ashland, OR), Exotech Inc. (Pompano Beach, FL), and JX Nippon Mining & Metals USA Inc. (Chandler, AZ).

Indium-Tin Oxide.—Production of indium-tin oxide (ITO) was the leading global use of indium (Indium Corp., 2016). ITO is principally used as a transparent, electrically conductive, thin-film coating on flat-panel displays—most commonly, liquid crystal displays (LCDs). In 2015, global ITO production capacity (excluding China) decreased by 6% to 1,980 t/yr. Four ITO producers, Corning Precision Materials Korea Co. Ltd. and Heesung Metal Ltd. in the Republic of Korea and JX Nippon Mining & Metals Corp. and Mitsui Metal Mining Co. Ltd. in Japan, accounted for about 90% of capacity. Capacity utilization at global ITO facilities, excluding China, was estimated to be about 60% in 2015, a decrease of 10% from that of 2014 (Roskill's Letter from Japan, 2016c). Globally, a significant amount of indium was reclaimed in the ITO recycling process and reused for the production of ITO. About 1,200 t/yr of indium can be reclaimed from ITO recycling (Indium Corp., 2016).

Alloys.—Indium-containing alloys were thought to be the second leading global end use of indium and were commonly used as solders in a wide range of applications owing to indium's high ductility and malleability, high thermal conductivity, and low melting point. Indium-lead solders were used to inhibit the leaching of gold components in electronic equipment. Indium-silver alloys or pure indium foil were used as thermal interface materials in electronics (a substance used to seal a heat-generating surface to a heat sink, filling microscopic air voids to allow for effective heat transfer). Certain indium-tin alloys were used as bonding agents between nonmetallic materials. Indium was also used in dental alloys, in low melting temperature alloys for fuses, as a substitute for mercury, and in white gold alloys.

III-V Semiconductor Materials.—An important use of indium was for III-V semiconductor materials, most commonly indium phosphide (InP) in optoelectronic devices (such as laser diodes) for fiber-optic communications. InP was mostly produced in Asia, followed by Europe and the United States, in descending order of quantity (Beijing 9Dimen International Information Consulting Co. Ltd., 2014). Companies that produced InP polycrystalline ingot or substrates included AXT Inc. (headquartered in Fremont, CA, with manufacturing facilities in China), Crystacomm Inc. (Mountain View, CA), InPact Inc. (France), JX Nippon Mining and Metals Corp. (Japan), Phostec S.R.O. (Slovakia), Sumitomo Electric Industries Ltd. (Japan), and Wafer Technology Ltd. (United Kingdom). The value of InP shipments in Japan, the leading producer of InP substrates, increased by 32% in fiscal year 2015 (April 1, 2015–March 31, 2016) compared with the value of shipments in the previous fiscal year owing to increased demand for fiber-optic communication devices and components used for high-speed communication and cloud computing networks (Roskill's Letter from Japan, 2016a).

[1]Deceased.

In July, AXT acquired Crystacomm, a U.S. producer of advanced InP substrates in Mountain View, CA. AXT planned to transfer Crystacomm's manufacturing equipment to AXT's facility in Fremont, CA. According to the company, the number of global InP manufactures remained limited owing to the technical difficulty of producing substrates that meet the specifications needed for electronic and optoelectronic applications (AXT Inc., 2015).

Other.—Indium was used in the manufacturing of copper-indium-gallium-selenide (CIGS) thin-film photovoltaic solar cells. CIGS thin-film cells accounted for 2% (2.1 gigawatts) of global solar cell production in 2015. Crystalline silicon continued to be the dominant solar cell-type, accounting for 93% of global production (National Renewable Energy Laboratory, 2016, p. 68). An estimated 40 t of indium was consumed globally for the production of CIGS solar cells (Roskill's Letter from Japan, 2016c). Solar Frontier K.K. (Tokyo, Japan) was thought to be the only mass producer of CIGS solar cells in 2015. The company operated three CIGS plants in Japan with a combined capacity to produce approximately 1 gigawatt per year of solar cells. (Solar Frontier K.K., undated). In April, Solar Frontier announced that it had completed the construction of a CIGS solar cell production plant [150-megawatt-per-year (MW/yr) capacity] at Ohira-mura, Miyagi Prefecture (Tohoku region), which was built in response to increased demand for solar cells in Japan (Solar Frontier K.K., 2015).

Indium was also used for the production of the semiconducting compound, indium gallium zinc oxide (IGZO), in organic light-emitting diode (OLED) displays and LCDs. IGZO has replaced amorphous silicon as the thin-film transistor in some displays because it allows for more pixels per square inch on small displays and ultra-high definition on large displays. IGZO displays also requires less voltage to operate. Sharp Corp. (Japan) consumed IGZO for the production of small- and medium-sized high-performance LCD panels for smartphones and tablets at its Kameyama Plant No. 2 in Japan (Cammell, 2012). Although IGZO had yet to be used commercially in large-screen LCD displays, LG Display (Republic of Korea) has been using IGZO in its OLED televisions (Harrower, 2015). Indium consumption for the production of IGZO remained level in 2015 at 20 t (Roskill's Letter from Japan, 2016b).

Prices

In 2015, indium prices decreased significantly. The average monthly Metal Bulletin free market price for indium decreased by almost 60% during 2015, averaging $628 per kilogram in January and falling to an average of $255 per kilogram in December. The average annual Platts Metals Week New York dealer price range for indium [99.99% minimum purity in minimum lots of 50 kilograms (kg)] averaged about $580 to $605 per kilogram in the first quarter, $530 to $560 per kilogram in the second quarter, $470 to $515 per kilogram in the third quarter, and $440 to $500 per kilogram in the fourth quarter.

Foreign Trade

During 2015, U.S. imports for consumption of unwrought indium metal and indium powders were 140 t, a 14% increase from the 123 t imported in 2014 (table 1). Leading suppliers in 2015 were Canada (27%), China (26%), and France (15%). Imports of indium from China increased substantially in 2015 to 36 t after several years of reduced import levels (15 t imported in 2012, 8 t in 2013, and 4 t in 2014), coincident with the operation of the Fanya Metal Exchange (Fanya), which opened in 2011 and closed in 2015. Data on indium exports were not available because there was no exclusive domestic export Schedule B code for unwrought indium and indium powders.

World Review

Global production of primary indium decreased by 14% in 2015 from that of 2014 mostly as a result of decreased production in China (table 3). China was the leading producer, followed by the Republic of Korea, Canada, and Japan. Primary indium was recovered mainly from the residues generated during the smelting of zinc concentrates. Although an important factor, global changes in zinc mine production may not be an indicator of a corresponding change in the production of indium. It has been estimated that only about 35% of the indium contained in zinc concentrates reaches refineries that are capable of extracting and producing indium. Data on the amount of secondary production were not available; however, market sources estimated that up to 1,200 t/yr of indium can be reclaimed from ITO recycling. Global consumption of indium was about 1,440 t in 2015, essentially unchanged from that of 2014 (Indium Corp., 2016).

Australia.—In July, Nyrstar announced that it would receive funding from the government of Tasmania to support investments in the company's zinc smelter in Hobart. A portion of the funding would be used to construct a leach plant that would enable the smelter to separate minor metals, including indium and germanium, from base metal concentrates. The investment project was part of a larger, company-wide strategy to debottleneck its smelters, build additional fuming capacity, and increase minor metals extraction (Nyrstar NV, 2015).

Belgium.—Indium metal was produced at Umicore's precious metals refinery at Hoboken. A specialty metals plant at the refinery had the capacity to recover 50 t/yr of indium from dusts and residues generated by the facility's lead refinery (Smith, 2013; Umicore NV, 2015).

Bolivia.—Sinchi Wayra S.A. (a subsidiary of Glencore International plc, Baar, Switzerland) was a significant producer of indium-bearing concentrates, which were exported and processed elsewhere.

Canada.—Refined indium was produced at Teck Resources Ltd.'s metallurgical complex at Trail, British Columbia, as a byproduct of processing lead-zinc concentrates. Indium production capacity at Trail was last reported to be 75 t/yr in 2005 (Teck Cominco Ltd., 2006, p. 27).

China.—China was the leading producer of refined indium, accounting for 46% of global primary refined production in 2015. Production was estimated to have decreased by 24% in 2015 from that of 2014 in response to decreasing indium prices.

China's indium consumption was reported to have increased in 2015 from that of 2014, but the actual amount was not disclosed (Minor Metals Monthly, 2016). China consumes indium mostly for the production of ITO (about 75%) and alloys (about 20%). In June 2014, Umicore and Vital Materials Co., Ltd. (China) announced plans to build an ITO production plant in Qingyuan, Guangdong Province. The 200-t/yr plant would produce planar and rotary targets for thin-film transistor LCDs, and production was projected to begin in the first half of 2016 (Minor Metals Monthly, 2016). The joint venture would be referred to as Umicore Vital Thin Film Technologies and was created with the support of China's leading LCD display producer, BOE Technology Group Co. Ltd. In recent years, China has been actively developing its domestic ITO industry in an effort to move away from being a net importer of ITO; the country has been nearly 100% import reliant on Japan, the Republic of Korea, and Taiwan for the type of ITO sputtering targets needed for the production of advanced display technologies (Metal Bulletin, 2014a; Smith, 2014).

Large amounts of indium metal have accumulated in commodity exchange warehouses in China—most notably, the Fanya Metal Exchange. Fanya was established in Kunming, Yunnan Province, in 2011 as a platform for private investors, producers, and consumers to spot trade minor metals. By early 2013, indium was trading at prices that were 40% more than the prevailing domestic spot prices in China as demand for indium from private investors surged. News sources indicated that the exchange became a market of first resort for producers in China and lead to a significant buildup of indium stocks in the exchange's warehouses. In May 2013, Fanya's warehouses reportedly held 1,000 t of indium, and by yearend 2014, the stock level had reportedly increased to about 3,470 t (Metal Bulletin, 2015a). In the fourth quarter of 2014, the Yunnan Securities Regulatory Bureau launched an investigation into the activities of Fanya and concluded that the exchange's investment activities were questionable. In response, Fanya introduced two new trading rules in December 2014, including the "T 5" rule, which restricted investors from buying or selling the same commodity within 5 days of a transaction, and the "real-name" rule, which identified company and dealer names during the transaction process (Chao, 2014). In July 2015, Fanya canceled its main financial investment product, the "Ri Jin Bao," in order to help alleviate the exchange's low liquidity issues. The Ri Jin Bao reportedly guaranteed investors annual returns as high as 13.68% with the collected interest available to be withdrawn by investors at any time. Fanya also announced that investors would only be allowed to trade ammonium para-tungstate, bismuth, germanium, and indium on a physical basis beginning August 31 rather than through its investment products. In response to Fanya's announcements, investors began to protest the exchange's actions with some investors claiming they had not been able to retrieve their funds since April. In August, Fanya entered into a debt-restructuring plan, and investors reportedly met with the China Securities Regulatory Commission (China's stock market regulator) and Provincial-level authorities to dispute Fanya's actions. In October, the Yunnan Provincial government requested that the Kunming municipal government take measures to protect the legal rights of Fanya's investors, and in response, the Kunming government began an audit of Fanya's financial and trade data as well as an inspection of Fanya's material stockpiles (Metal Bulletin, 2015b). By November, the Kunming government took over Fanya. At the time Fanya's Web site was shut down in November, exchange warehouses reportedly held about 3,610 tons of indium, equivalent to more than 4 years of primary production, and the listed price of indium on the exchange was $1,190 per kilogram, significantly more than prevailing domestic market prices. In December, the Kunming municipal government announced that it had launched a criminal investigation into Fanya (Gu, 2015a, b; Zhao, 2015).

Other exchanges in China trading indium included the Shaanxi Nonferrous Metal Exchange (which began trading indium in June 2014), the South Rare Precious Metals Exchange, the Tianfu Mercantile Exchange, and the Wuxi Stainless Steel Exchange (Burton, 2013; Metal Bulletin, 2014b).

China returned to being a net exporter of indium in 2015 owing to comparatively higher international prices and a lack of domestic investor demand for indium following the collapse of Fanya. According to China's customs statistics, China imported 50 t of indium and exported 89 t. Exports were shipped predominately to the Republic of Korea (46%), Japan (37%), and the United States (15%). However, the Republic of Korea, Japan, and the United States reported a combined total of 135 t of indium imported from China in 2015 (Global Trade Information Services Inc., 2016).

China regulates its indium production industry through the imposition of an export duty and quota system. In May, China removed the 2% export duty on indium. However, indium producers and traders in China were still required to apply for and receive an export license from the Ministry of Commerce in order to export indium. In 2015, 16 companies were approved to export indium, and the total export quota was set at 228 t. Companies with the largest export quotas included Zhuzhou Keneng New Material Co. (75 t), Guangxi Debang Technology Co. Ltd. (35 t), China Minmetals Non-Ferrous Metals Co. Ltd. (33 t), and Nanjing Germanium Technology Co. Ltd. (29 t). In December, the Ministry of Commerce announced that the export quota for the first half of 2016 would be 162 t, slightly more than the export quota in the first half of 2015, but the number of quota recipients decreased to 14 companies. Zhuzhou Keneng New Material Co. Ltd. and Guangxi Debang Technology Co. Ltd. accounted for most of the announced total export quota (Ministry of Commerce, Foreign Trade Division, 2014, 2015, 2016; Shen, 2015).

In an effort to stimulate the domestic indium market, China's State Reserve Bureau (SRB), which manages the country's critical materials stockpile, purchased 100 t of indium in November from five local minor metal producers for a price of $205 (1,310 yuan) per kilogram, about 7% more than the average domestic price at the time (Xu, 2015).

France.—Nyrstar NV (Balen, Belgium) produced 99.998% indium metal at its zinc smelter in Auby. In 2015, Auby's indium production decreased by 5% from that of 2014 to 41 t owing to technical issues in the first half of the year, a planned plant stoppage in the third quarter, and a fire in November. Nyrstar projected that the indium cement production line would remain

shutdown for the first half of 2016 to repair the fire damage, resulting in a 50% decrease in indium production in 2016 from that of 2015. Nyrstar was increasing the indium production capacity at Auby to 70 t/yr from 45 t/yr, and commissioning of the new equipment was expected to take place at the end of the third quarter of 2016 (Nyrstar NV, 2016, p. 9, 16).

Japan.—Japan was a significant producer and recycler of indium. Dowa Metals and Mining Co. Ltd. had the capacity to produce about 70 t/yr of primary indium and to recover up to 150 t/yr of secondary indium at its zinc smelter and rare metals recycling facility in Akita. Other primary producers included Mitsui Mining and Smelter Co. Ltd. (Takehara plant) and Sumitomo Metal Mining Co. Ltd. (Harima smelter). Asahi Pretec Corp. had the capacity to produce 200 t/yr of secondary indium at its ITO target recycling plant at Fukuoka (Metal-Pages, 2008). Other secondary indium producers included JX Nippon Mining and Metals, Mitsui Mining & Smelting Co. Ltd., Sumitomo Metal Mining Co. Ltd., and Toho Zinc Co. Ltd. In September, Sumitomo ended its production of zinc products and byproducts (including indium) at its Harima smelter in order to expand the plant's production of nickel sulfate for secondary batteries (Sumitomo Metal Mining Co. Ltd., 2014, undated).

Japan was a leading consumer of indium, mostly for the production of ITO. ITO producers included Mitsui Mining & Smelting, which operated an ITO manufacturing plant at Omuta, and Nippon Mining & Metals, which operated the world's leading ITO production plant at Isohara near Tokyo (Roskill's Letter from Japan, 2016c).

Japan's imports of indium metal, powder, and scrap increased by 36% to 226 t in 2015 from that of 2014. Leading import sources in 2015 included the Republic of Korea (45%), China (18%), Canada (17%), and Taiwan (17%) (Global Trade Information Services Inc., 2016).

Korea, Republic of.—Korea Zinc Co. Ltd. was a significant producer of primary and secondary indium at its Onsan zinc refinery (260-t/yr capacity, including secondary). Young Poong Corp. had the capacity to produce up to 30 t/yr of indium at its Sukpo zinc refinery (Young Poong Corp., 2016). The Republic of Korea was also a notable consumer of indium. Major consumers were the ITO producers, Heesung Metal and Corning Precision Materials Korea.

The Republic of Korea imported 172 t of indium (metal, powder, and scrap) in 2015, 74% more than that in 2014, mostly from Taiwan (74%), China (35%), and Japan (19%), and exported 127 t predominantly to Japan (83%) (Global Trade Information Services Inc., 2016).

Russia.—Chelyabinsk Zinc Plant OJSC and Ural Mining and Metals Co.'s Electrozink smelter produced refined indium. Most of Russia's refined indium output was thought to be exported.

Outlook

Demand for indium is expected to decrease in 2016 following the closure of Fanya. In the medium term, consumption of indium is projected to continue to follow demand for ITO for LCD production. Market research firm IHS Technologies forecast that unit shipments of LCD glass would decrease in 2016; however, overall LCD glass demand (in terms of total area) is expected to increase by 13% from 2015 through 2018 as the average screen sizes for LCD televisions, desktop monitors, and tablets are expected to increase (Uno, 2016).

On the supply side, China is expected to continue to be the main global supplier of primary indium metal with some additional primary production capacity anticipated in France. Several indium-containing exploration or development projects, mostly in Canada, South America, and the United States, are advancing, but it is uncertain as to when or whether these projects will come on stream.

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TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT INDIUM AND INDIUM POWDERS BY COUNTRY[1]

	2014		2015	
Country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Argentina	--	--	600	$300
Belgium	15,700	$7,570	12,400	4,650
Canada	25,200	17,400	37,800	14,700
China	3,990	2,750	36,200	12,300
France	25,500	17,300	21,600	9,450
Germany	493	327	342	125
Hong Kong	1,620	1,090	1,680	484
Israel	--	--	1	5
Japan	6,550	4,380	2,540	927
Korea, Republic of	14,900	10,200	10,100	4,780
Laos	565	38	500	264
Peru	4,130	2,780	1,450	801
Russia	514	357	514	272
Taiwan	21,300	14,600	11,600	4,560
United Kingdom	2,470	2,000	2,910	1,850
Total	123,000	80,800	140,000	55,500

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 2
ESTIMATED WORLD PRIMARY INDIUM PRODUCTION CAPACITY[1]

(Metric tons)

Country[2]	Major operating company	Location of main facilities	Primary annual capacity
Belgium	Umicore NV	Hoboken	50
Canada	Teck Resources Ltd.	Trail, British Columbia	75
China	Guangxi Debang Technology Co. Ltd.	Liuzhou, Guangxi	85
Do.	Guangxi Hechi Jinhe Mining and Smelting Co. Ltd.	Hechi, Guangxi	10
Do.	Guangxi Tanghan Zinc & Indium Co. Ltd.	do.	30
Do.	Hsikuangshan Twinkling Star Antimony Co. Ltd. (China Minmetals Group)	Lengshuijiang, Hunan	7
Do.	Huludao Nonferrous Metals Group Co.	Huludao, Liaoning	60
Do.	Hunan Jingshi Group Co. Ltd.	Zhuzhou, Hunan	40
Do.	Laibin Smelter [Liuzhou Huaxi (China Tin) Group Co.]	Laibin, Guangxi	50
Do.	Liuzhou Zinc Products Co.	Liuzhou, Guangxi	20
Do.	Nanjing Germanium Co. Ltd.	Nanjing, Jiangsu	150
Do.	Nanjing Sanyou Electronic Material Co. Ltd.	do.	50
Do.	Shaoguan Smelter (Shenzhen Nonfemet Co.)	Shaoquan, Guangdong	25
Do.	Tibet Summit Industry Co. Ltd.	Xining, Qinghai	15
Do.	Xiangtan Zhengtan Nonferrous Metal Co. Ltd.	Xiangtan, Hunan	75
Do.	Yintai Technology Co. Ltd.	Liuzhou, Guangxi	40
Do.	Yuguang Gold-Lead Co. Ltd.	Jiyuan, Henan	20
Do.	Yunnan Chengfeng Nonferrous Metals Co. Ltd.	Gejiu, Yunnan	10
Do.	Yunnan Hualian Zinc and Indium Co. Ltd.	Wenshan, Yunnan	60
Do.	Yunnan Luoping Zinc & Electricity Co. Ltd.	Luoping, Yunnan	20
Do.	Yunnan Mengzi Mining and Smelting Co. Ltd.	Honghe, Yunnan	60
Do.	Zhuzhou Smelter Group Co. Ltd.	Zhuzhou, Hunan	60
France	Nyrstar NV	Auby	48
Japan	Dowa Metals and Mining Co. Ltd.	Iijima, Akita	70
Do.	Mitsui Mining and Smelting Co. Ltd.	Takehara, Hiroshima	NA
Do.	Sumitomo Metal Mining Co. Ltd.	Harima, Hyogo	NA
Korea, Republic of	Korea Zinc Co. Ltd.	Onsan	160
Do.	Young Poong Corp.	Sukpo	35
Peru	Doe Run Peru S.R. Ltda.	La Oroya	5
Do.	Votorantim Metais Ltda.	Cajamarquilla	50
Russia	Chelyabinsk Zinc Plant OJSC	Chelyabinsk	15
Do.	Ural Mining and Metals Co.	Vladikavkaz	5

Do., do. Ditto. NA Not available.
[1]Estimated data are rounded to no more than two significant digits.
[2]For China, facilities that consume mineral concentrates are included as well as processors that consume unrefined indium.

TABLE 3
INDIUM: ESTIMATED WORLD PRIMARY PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country[3]	2011	2012	2013	2014	2015
Belgium	30,000	30,000	30,000	28,000	20,000
Canada	77,000	65,000	70,000	67,000	70,000
China[4]	380,000	405,000	415,000	460,000	350,000
France	--	13,000	33,000	43,000	41,000
Japan	70,000	71,000	72,000	70,000	70,000
Korea, Republic of	155,000	180,000	175,000	195,000	195,000
Peru	2,499 [5]	11,080 [5]	14,000	14,000	9,000
Russia	6,000	9,000	9,500	4,000	4,000
Total	720,000	784,000	819,000	881,000	759,000

-- Zero.

[1]Estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes data available through July 21, 2016.

[3]In addition to the countries listed, Kazakhstan and Ukraine may have produced primary indium, but available information is inadequate to make reliable estimates of output.

[4]May include secondary production.

[5]Reported figure.